REARING THE PAINTED LADY *CYNTHIA CARDUI* L. WITH PARTICULAR REFERENCE TO THE USE OF SEMISYNTHETIC DIET

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Introduction

This common and worldwide butterfly is usually quoted as feeding upon thistles (*Carduus* species being those most often cited) with the stinging nettle (*Urtica dioica*) given as a close second choice. A search of the more common and widely used butterfly books reveals that it has been found on a very wide range of plants and is even occasionally a pest on some of them (eg *Cynira* in France (Batra et al 1981)). In view of the fact that it is a notable migrant and of cosmopolitan distribution it is perhaps not surprising that it should be able to at least survive on such a wide range of foodplants as have been recorded. These are listed in Table 1. One does wonder, however, how many of the given foodplants are quoted from earlier works, rather than original observations. It seems quite likely that over parts of its range, local populations may well have distinct feeding preferences and be unable to survive on plants utilised by other populations which may be spatially separated by thousands of miles. Nevertheless it does seem from statements made in the literature over a long period of time that thistle and nettle are what the larvae are most often to be found on, and have most frequently been reared on, and that the other quoted foodplants are much more rarely utilized.

In 1985 there was a large early immigration of the painted lady into England and while these did not reach Cambridge, thanks to the generosity of Dick Burgess who supplied me with stock I was able to carry out extensive rearing experiments and to develop a semisynthetic diet for the larvae.

The recorded foodplants

Painted lady larvae have been recorded from a wide variety of foodplants and a record of those stated in some of the commoner books over the past two centuries is given in Table 1. By far the commonest foodplant quoted, in all 16 books consulted, is thistle, either as 'thistle(s)', as a specific member of the genus *Carduus* or *Cirsium*, or just the generic name is given. Taxonomically these two genera are confused and species have changed over from time to time. In view of the difficulty in identification, not to mention

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taxonomic shifts from one genus to another, it is perhaps not too surprising that some authors are reluctant to commit themselves to species. Next in order of precedence is nettle with 12 mentions while *Malva* and *Echium* are equal third.

The majority of the recorded foodplants belong to the Compositae with a scattering of other families of which the Urticaceae and Malvaceae appear the most favoured. I am inclined to dismiss Harris's quote of dock as being due to this plant being nearly always found alongside nettles and thistles anyway, for no other author in two centuries has confirmed it. Two of the authors cited (Rowland-Brown and Batra *et al.*) give a number of foodplants not otherwise mentioned in English literature and it is interesting to find that in both their cases they have quoted from Continental or Indian sources and it is extremely likely that the painted lady utilizes alternative foodplants in different regions of its range, for it is, after all, of world-wide distribution.

It is difficult to evaluate to what extent authors have stated a foodplant from personal knowledge or have copied from some previous author. Like many other Lepidoptera the painted lady may well be found to accept in captivity foodplants it does not eat in the wild and in view of Warren's recent finding that *C. nutans* (interestingly enough placed first by Stainton) is preferred in nature and my own failure with thistle (see below), I feel that much more observation on the laying preferences of the adult butterflies needs to be done.

Materials and Methods

The stock obtained from Dick was reared up on stinging nettle and from the resultant adults and their progeny, some tens of thousands in all, various feeding experiments were carried out. All stages were kept in a heated insectary which has been in use for many years for the continuous rearing of *Pieris brassicae* L. and many other species of insect from time to time. The light is natural daylight which is extended when necessary to 18 hours per day by means of an 80W fluorescent strip light controlled by a timeswitch and the temperature is kept between 20–25° C by means of a 2 kW fanheater controlled by a thermostat. However, during very warm weather the daytime temperature exceeds 25° and has been known to go above 30° for a few hours during the day.

The butterflies were kept in a corner of the building, in a cage 18 inches square and 30 inches high, the two outside sides of the cage being of glass which formed part of the building while the inner sides and top were of netting. This corner of the insectary catches the sun from mid-morning to evening. The butterflies were given 10% white sugar solution either in artificial flowers as has been described for *P. brassicae* (Gardiner 1985), or else in a plastic dish

FOODPLANT	AUTHORITIES
COMPOSITAE	
Thistle(s)	Harris, Samoulle, Humphreys & Westwood, South, Rowland-Brown,Holland,Scorer,Howarth,Cribb, Batra et al.,Heath et al.
Carduus arvensis	Rennie,Frowhawk,Stokoe,Allan,Cribb
C.lanceolatus	Humphreys & Westwood, Stainton,Frowhawk,Scorer
C.nutans	Stainton, Frowhawk,Stokoe,Allan,Batra et al.
C.crispus	Stokoe,Allan
C.acanthoides	Stainton, Frowhawk, Batra et al.
C.acaulis	Frowhawk
C.edelbergii	Batra et al.
C.pycnocephalus	Batra et al.
C.tenuiflorus	Batra et al.
C.vulgare	Stokoe
C.palustre	Stokoe
Carlina	Batra et al.
C.vulgaris	Allan
Onopordum	Batra et al.
O.acanthium	Allan, Stokoe
Arctium	South, Scorer, Howarth
A.minus	Allan
A.lappa	Rowland-Brown, Stokoe, Frowhawk
Filago germanica	Allan, Stokoe
F.arvensis	Rowland-Brown
Gnaphalium	Rowland-Brown
Silybum	Rowland-Brown, Batra et al.
Cynara	Humphreys & Westwood, Rowland-Brown,Batra et al., Cribb
Centaurea	Batra et al.
Carthamus	Batra et al.
Cnicus	Batra et al.
URTICACEAE	
Nettle(s)	Harris, Rennie, Humphreys & Westwood, South,Holland, Rowland-Brown,Scorer,Frowhawk,Howarth,Stokoe,Allan, Batra et al.
Parietaria	Rowland-Brown
BORAGINACEAE	
Echium sp.	South, Scorer,Howarth
E.vulgare	Rowland-Brown,Frowhawk,Stokoe,Allan
Nonnea pulla	Rowland-Brown
MALVACEAE	
Malva	Rennie,Humphreys & Westwood, South,Scorer,Howarth
M.sylvestris	Rowland-Brown,Frowhawk,Stokoe,Allan
Althea	Heath et al.
CHENOPODIACEAE	
Chenopodium	Rowland-Brown,Allan
UMBELLIFERAE	
Eryngium	Rowland-Brown
LEGUMINOSAE	
Astragalus	Batra et al.
Runner beans	Allan,Howarth
POLYGONIACEAE	
Docks	Harris

Table 1: published foodplants of the painted lady.

containing a blue plastic pot scourer, which gives an ideal foothold to feeding butterflies. The sugar was supplemented with real flowers from time to time, especially buddleia, mallow, *Lavetera,* burdock and *Sedum.*

The buddleia was obtained from a bush growing in my garden, the *Lavatera* was obtained from a local garden centre, but all the nettle, mallow, burdock and thistle used was obtained from a field laid down to a crop of cabbage on the one side and sugar beet on the other and were essentially 'weeds' flourishing along the edges of a crop. Praise be that some farmers are friendly enough to us entomologists!

The adults and Oviposition

Potted stinging nettle was normally supplied for oviposition and eggs were freely laid on this plant. It was observed, however, that eggs were being laid elsewhere, particularly on the flowers of the buddleia and also on the netting sides of the cage when, by chance, a stinging nettle had been left alongside, out of touch of, but within visual and (possibly!) olfactory range. Eggs were observed to be laid freely on thistle, burdock, *Malva* and *Lavatera* but not on *Sedum*, valerian, Michaelmas daisy, nor any of the other various flowering plants occasionally put into the cage either for feeding purposes or just as foliage on which the butterflies could settle for sunning themselves during the day or roost at night. In view of the subsequent failure of the larvae on buddleia it was rather surprising that even when nettle or other suitable foodplants were also present eggs continued to be laid on this unsuitable plant.

Under the conditions they were kept, whenever the sun was shining into their cage the butterflies were very active and fed and mated readily. It was particularly noticed that they spent a considerable amount of their time 'sunning' themselves with wings open. They also went early to roost, late afternoon or early evening in summer and as soon as the light started to fade in the autumn and winter. Roosting was a distinctly gregarious activity, the corners of the cage, both upper and lower, being preferred. Once roosted they were very loth to being disturbed and would sit quite tight even when prodded. In this they are quite unlike *P. brassicae* which remains very active as long as there is any sort of light available and will even take off when disturbed in the dark.

Although detailed records were not kept, a small number of individuals were marked to see what happened to them and it was noticed that when freshly emerged butterflies were put into the cage, some 10–20% would be dead within a few days and it is a reasonable assumption that these had failed to feed and settle down to cage life.

Once they had survived the first few days then their life expectancy was about a month and a number of specimens lived for at least two months with one particular individual just exceeding three months.

Rearing on stinging nettle

Eggs laid on nettle were allowed to hatch and since there were usually far too many larvae on the plant for it to support in comfort, either another plant was placed alongside and touching, so that the larvae transferred themselves, or else the egg-bearing leaves were cut off and placed in plastic boxes with cut nettle foliage or semi-synthetic diet. It was found that if the cut nettles were placed in a jar of water and the foliage was then covered with a plastic bag, when all was kept under refrigeration (4° C) it remained usable for 7–10 days whereas in the warmth of the insectary, or even outside, nettles did not last more than a couple of days. The older foliage was found to deteriorate much faster than the young growth.

Perhaps more interesting was that the larvae showed a definite preference for younger, fresh foliage and in autumn, when the previous years nettles had seeded and the new growth was about a foot high, then if these plants were uprooted they too would keep well under refrigeration and could also be potted up *on masse* to give ideal pabulum to the larvae.

At first attempts were made to keep the larvae at quite high densities, some 50 or so in plastic boxes 7 x 5 x 2 inches in size. This seemed to be working at first and the larvae developed well up to the third instar, but after this there was very high, sometimes 100%, mortality and it was not until the density was lowered to only about a dozen per box that the mortality became neglegible. It was also observed, however, that even when the larvae were thinned out at the third instar, the earlier crowding had had a deleterous effect, for the later mortality, even when the larvae were then being kept singly, was of the order of 50–100%. When, however, the larval densities were kept down so that no more than 10–20 were in each container from the beginning then later mortality did not exceed 5–10% and in many batches was nil.

If the larvae were left crowded on the oviposition plants, they immediately after hatching would wander off and be lost. If they could be caught at this stage it was not too difficult, but very tedious, to gather them up with a sable-hair brush and transfer them directly into individual pots of semi-synthetic diet.

It soon became obvious that some 'limiting' factor was at work. The potted nettle plants were all rather small and seldom exceeded a dozen leaves on each plant none of which exceeded 1½ square inches in area. On such a plant hundreds of eggs would be laid. When left

to their own devices, as mentioned above, most of the newly hatched larvae would wander off the plant and, if not gathered up, be lost. By the second instar there were left, at most, some 3 or 4 larvae per leaf on the plant.

On nettle, therefore, the early instars were reared either on growing potted plants or on cut foliage in plastic boxes. The later instars were all reared on cut foliage in pots of water and were kept in airy cages of about 1½ cu ft at a density not exceeding 40 per cage. As already stated, provided the early instars had not been kept crowded, losses did not exceed 5% and were often due to accidents rather than other causes.

A continuous brood was kept in this way on nettle in order to act as a control to the other foods being used. In general the larvae resulting from eggs laid over the same period by a given group of adults were divided between the diet or other plants being offered.

Attempts to rear on thistles

Some potted thistles (*Carduus arvensis*) were put into the cage on several occasions and eggs were laid on them. These duly hatched and the larvae commenced to feed and, as had happened when the nettles were overburdened with too many eggs, when the larvae had hatched, the surplus wandered off the plant. However, in no case did any of the larvae feeding on thistle survive beyond the third instar. Just in case this could have been due to the fact that they were so overcrowded in the very early stage, some further potted thistles were put into the adult cage for a few minutes only and watched until only a few eggs had been deposited. These duly hatched and the larvae started to feed on the thistle, but again none survived beyond the third instar. At the same time contemporary larvae were flourishing with minimum mortality on potted nettle as already described. Other larvae were removed on hatching and split into two batches. One half were given thistle, this time *Carduus vulgare* and the other half nettle, and were put into plastic boxes at the low density of 10–20 per box already referred to. Again those on the nettle survived and those on the thistle did not. In view of the fact that thistles are quoted in nearly all the books as being a main foodplant of the painted lady, I have no valid explanation for these findings, but some theorising which is considered further under the Discussion below. The thistles were obtained from the same field as were the nettles, the two being totally intermingled as 'weeds' in a cabbage crop, and it is therefore impossible that they were somehow contaminated with any poison, for if they had been then so too would be the nettles used, not to mention cabbage from the same source being used to feed other species.

Rearing on Mallows

When reared on common mallow *Malva sylvestris*, either in plastic boxes or on growing or cut foliage in water, and at low densities, at least 90% of the larvae pupated and produced butterflies. This survival rate is comparable with those on nettle.

Although eggs were laid so freely on it, no larvae survived beyond the first instar on the tree mallow (*Lavateria olbia*) and indeed they were clearly very unhappy on it and would wander off even when only a few were present on a large plant and all of the larvae that nibbled the leaf of this plant died as if they had been poisoned. Indeed it was noticed that even those that, after eating, were allowed to transfer to nettle, still died within a day or two. This plant is incorrectly sold by some garden centres as common mallow.

Rearing on Burdock

Eggs were particularly laid in between the bracts of the flowerheads of the giant burdock (*Arctium lappa*) but the larvae failed to eat at this point and would wander off onto the leaves. Eggs laid here, however, did not all go to waste, as by putting the cut-off seed head into a confined space with some semisynthetic diet, many would transfer readily onto it, the disadvantage being that the seedheads clearly carried fungus spores which in some cases so found the diet to their liking that they took over and swamped the larvae. This could happen overnight so fast did the fungus grow and before all the eggs had hatched. There was very considerable mortality in the early stages which I considered to be due to the fact that the plants were at the time of use old and running to seed with the result that most leaves were hard and sere. In the Cambridgshire fens this plant grows to an enormous size, often 7–8 foot high and 5 foot in diameter. Nevertheless, in spite of the losses, once the larvae were established on the freshest foliage that could be found and had managed to survive until the third instar, nearly all then fed up to pupation and produced butterflies. This burdock did not keep well in water (which could have been due to its being already senescent) and all larvae on it were kept in plastic boxes. No potted examples of this plant were available for testing. In spite of the high mortality on this foodplant, I believe, in view of the survival of the later instars, that the early mortality was due to its being used late in the season when the plants were hard, sere and senescent and there is no doubt in my mind but that survival on fresh young growth would be equal to that obtained on mallow or nettle.

Failure to rear on buddleia

Flowers of buddleia (*Buddleia davidii*) were supplied to the butterflies for feeding purposes. This is not a recorded foodplant of the species and it was therefore a surprise to find that these flowers were being smothered with eggs. Thinking this might be a mistake on their part, due to nettle or other more normal foodplant not always being present in the cage (flowers for feeding were left permanently in the cage but plants for oviposition were removed every evening in order not to have a large age-spread of eggs), an experiment was done and close observation made, so that whenever buddleia flowers were present so too were nettles available for oviposition. Nevertheless, even when they had the clear choice of a natural and known suitable foodplant, the adults continued to lay on the buddleia. On the whole they preferred to deposit their eggs on the flowers rather than on the leaves.

The eggs so laid duly hatched and, as with overcrowding on other plants, most of the larvae wandered off. Nevertheless some did commence to feed, but were clearly unhappy and all of the early larvae found on buddleia wandered off and were lost. Later batches, therefore, were confined, at low densities, in plastic boxes and supplied with fresh buddleia leaf. Most, but not all, would start to feed. They were clearly not happy and would wander about their container, unlike those on the nettle which remained within the little silk tent they like to spin. About half of those that commenced feeding became second instar and a very few made it to the third instar. None survived beyond this. It was not easy to decide what they died from. The impression is that it was slow starvation due to a reluctance to feed at their normal rate, but it could also be that they were being slowly poisoned. The buddleia leaves clearly contained something not to their liking.

The most surprising thing about this result is not so much the larvae failing to survive, as the adults being so ready to lay on what is clearly a lethal pabulum. Most, if not all, butterfly species go to great lengths to avoid depositing their eggs an any plant their offspring will not survive on and in view of the adults partiality to buddleia flowers one wonders if under natural conditions eggs are also deposited thereon.

(*to be concluded*)